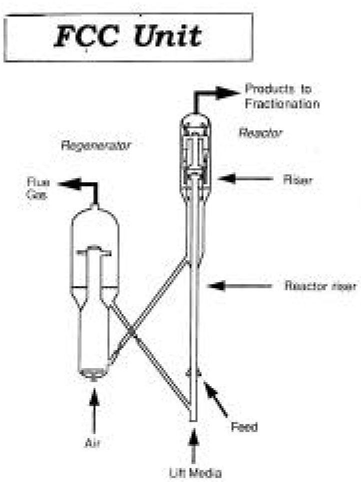
Process Evaluation Section

Advanced Fluid Catalytic Cracker Development

Problem/Opportunity

Refiners are under pressure to adjust their product slate and/or specifications in response to market forces, changing crude supplies, and environmental regulations (e.g., the 1990 Clean Air Act Amendments [CAAAs]). The CAAAs eventually required the refiners to reformulate their gasolines, and pressures are mounting for refiners to reformulate diesel fuels as well. The fluid catalytic cracker (FCC), a key refining process, can be used to alter product slates and/or increase yields. The key to achieving such changes is to develop a better understanding of the interaction of FCC riser hydrodynamics and cracking kinetics. This goal can be accomplished by developing advanced FCC Computational Fluid Dynamic (CFD) models (analytical design tools) that can be used to identify, define, and evaluate optimized FCC operating conditions and potential hardware improvements to alter the FCC product mix.



Schematic for Fluid Catalytic Cracker

Approach

Though a collaborative research and development agreement (CRADA) with UOP and CHEVRON, ANL has developed and validated an advanced three-dimensional, three-phase, cracking-reaction-CFD model. A phased experimental and theoretical program was pursued. Phase I of the project focused on the development of (1) a riser model based on a kinetic cracking model constructed from pilot-plant FCC kinetics data, (2) spray injection and particle/solid interactions models, and (3) a three-dimensional, three-phase CFD code with the cracking reaction model. Phase II focused on validation of the riser model by using data from pilot- and commercial-scale FCC units. The on-going Phase III effort will demonstrate the utility of the model by designing and implementing changes in a commercial-scale FCC unit to obtain a desired pre-determined shift in the product mix.

Results

Phase I and II have been completed. A simulation of the Chevron pilot-scale facility has been developed using ANL's Integral Cracking Flow (ICRKFLO) code. New models/methodologies have been incorporated into the code to (1) couple the hydrodynamics and cracking reaction rates, and (2) calculate species concentrations (product yields) using as many cracking reactions as desired. We have developed a particle/particle interaction model that allows the simulation to successfully predict the U-shaped solids' concentration profiles generally encountered in such flows. The team also developed and patented a methodology to extract cracking rate constants from a limited set of pilot-plant data. The FCC simulation has been successfully validated against pilot-scale and commercial FCC data. Trends in the impact of key operating parameters on product yields have been predicted, and excellent agreement between measured and predicted yield curves has been achieved.

Future Plans

Phase III, the demonstration of the utility and validity of the FCC riser model, will be completed soon. The model will then be made available to the entire refining industry through a workshop, where its use will be demonstrated and the results from the program will be presented.

Computed Optimal Gasoline Yield in an FCC Unit